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ABSTRACT

This issue of "CQ Researcher" examines the theme of computer networking in the classroom and discusses uses past and present. It begins with an essay by Christopher Conte that discusses: "Does computer networking really enhance learning? Are teachers adequately prepared to take advantage of computer networking? Will computer networking promote equality or widen the gap between poor and affluent Americans?" The "Background" section looks at barriers to use, the limited early role of computer assisted instruction, and the present, more advanced uses of computers. The "Current Situation" section contains brief articles on high costs and federal initiatives associated with computer networking. The "Outlook" section considers technology and educational reform. The "Sidebars and Graphics" segments include: (1) "Sharing Computers," a United States map with shadings that indicate ratios of students per computer; (2) "How an Imaginative California School District Takes Students Where Textbooks Can't Go"; (3) a "Technology in Schools" bar graph; (4) "Field Trips of the Future"; (5) a "Chronology" of key networking events since 1962; (6) "Networking Resources on the Internet Range from the Esoteric to the Practical"; and (7) a debate over whether computer networking improves instruction. Two annotated bibliographies, with a total of 39 recommended sources, are appended. (BEW)

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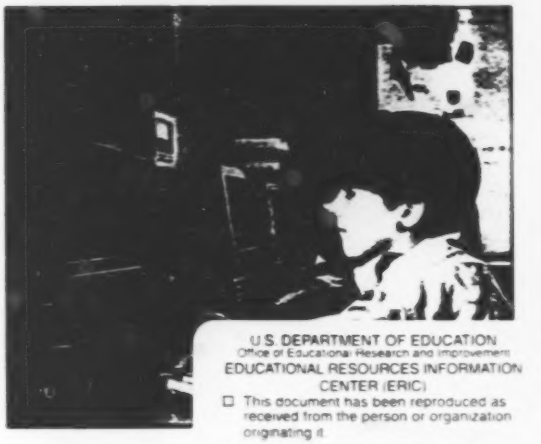
Networking the Classroom



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Can computer technology reform education?

A growing number of schools are rushing to get on the information superhighway. They view the ability to navigate telecommunications byways as vital to survival in the information age. Added impetus comes from school reformers, who say computer networks can link schools to the "real world," bring vast new stores of information into classrooms and teach children to become lifelong learners. Skeptics see the current fascination with technology as an expensive diversion and warn that the inherent conservatism of schools will thwart the reformers' dreams. The outcome may hinge on whether Americans accept the reformers' vision of a complete overhaul of the education system, and whether society matches its zeal for installing computer hardware with a commitment to train teachers to use it effectively.

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NETWORKING THE CLASSROOM

THE ISSUES

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Networking the Classroom

By Christopher Conte

The Issues

Yi-Lun Ding called it "Mission Possible." For a sophomore science project, Yi-Lun and a group of fellow students at Montgomery Blair High School in Silver Spring, Md., wanted to build a device to simulate how ozone is analyzed in the stratosphere. Concluding that his "research team" needed expert advice, he went to the school's computer lab and ventured out onto the Internet looking for help.

Yi-Lun searched the public data bases maintained by the National Aeronautics and Space Administration (NASA) and found the chief investigator of an ozone expedition in Antarctica. Then, he recalls, "I e-mailed him describing our project, and he referred me to the scientist who was responsible for detecting ozone, Jim Elkins. We corresponded through e-mail and learned the techniques he used in his experiment. We even received a videotape, articles his team wrote for Science and booklets from NASA, which helped with our presentation."

Yi-Lun doesn't explore cyberspace just to gather information. He also is an international "publisher," maintaining his own Internet "home page" where computer users worldwide can read his resume and his thoughts on such topics as the Endangered Species Act.

Computer advocates and education reformers consider students like Yi-Lun as models for the future of education in America. Actively engaged in challenging, real-world tasks, they sift through the raw materials of the information age to find cutting-edge data, learn directly from scientists and other experts and communicate their own ideas far beyond the walls of their schools. Their tools: computers connected to one another over the vast network known as the Internet. [1]

The idea of linking schools to the computer network has become one of the hottest education topics of the 1990s. President Clinton has said the U.S. should set a national goal of connecting every school to the information superhighway by the year 2000. "I want to get the children of America hooked on education through computers," Clinton said in a speech in California Sept. 21, adding, "we must make technological literacy a standard."

But Clinton's networking goal almost certainly is beyond reach. Currently, just 3 percent of the nation's elementary, middle and high school classrooms have Internet connections, and only about 16 percent of teachers use the Internet or computer-based communication services like America Online, CompuServe or Prodigy, according to the Denver research firm Quality Education Data Inc. [2] Linking the remaining classrooms could cost $30 billion or more, plus at least $5 billion in annual operating expenses. [3] Currently, schools spend under $3 billion of their $249 billion annual budgets on all forms of technology, according to McKinsey & Co., a New York-based consulting firm.

Some critics question whether the current fascination with computer networking is blinding us to more pressing needs. "Our schools face serious problems, including overcrowded classrooms, teacher incompetence and lack of security," notes Clifford Stoll, author of a popular critique of cyber culture. "Computers address none of these problems. They're expensive, quickly become obsolete and drain scarce capital budgets." [4]

Still, the idea of bringing computer networking to schools has captivated many policy-makers, educators and parents. In the process, it has spawned a vibrant dialogue about the way classrooms function, the relationship between schools and other institutions and, ultimately, even what students should be expected to learn.

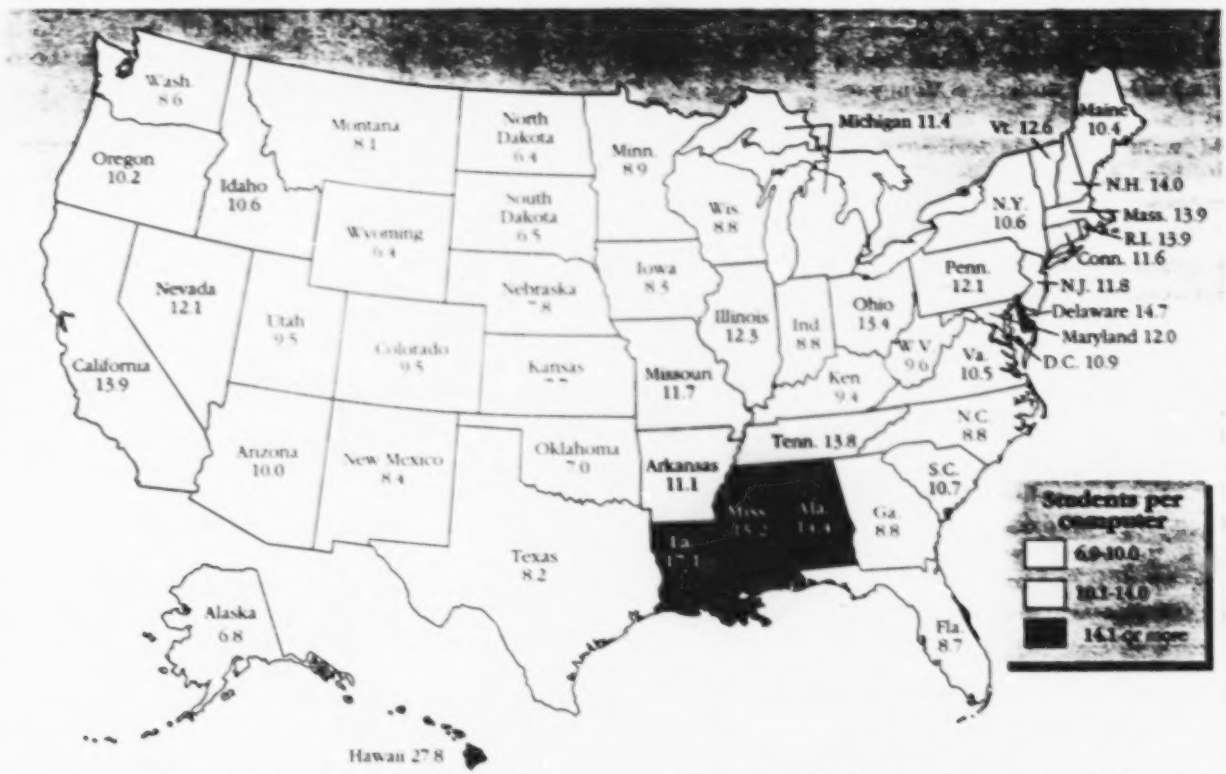
The push to connect classrooms draws much of its force from a vision that computer networks could serve as catalysts for fundamental reform of education. In the traditional classroom, teachers are the focal point of activity. They transmit an established body of knowledge to students, who are judged by their ability to absorb and repeat those basic skills and facts. But in the new, reform model, students assume more responsibility for setting their own educational goals and then develop skills to seek, sift and analyze information in pursuit of these objectives. (*See story, p. 926.*)

As for teachers, they "change from being the repository of all knowledge to being guides or mentors who help students navigate through the information made available by technology and interactive communication," says the National Academy of Sciences. "They help students gather and organize information, judge its value and decide how to present it to others." [5]

The idea of "student-centered" or "inquiry-based" learning traces its roots back at least to 18th-century philosophers like Rousseau. But it has gained added impetus as the economy has evolved from the mass production model of the 20th century to a 21st century "information age" model. As

Sharing Computers

More students have to share computers in Hawaii and Louisiana than in any other states. Wyoming has the lowest number of students sharing. Nationwide, there are an average of 10.5 students per computer.



Source: Quality Education Data Inc.

a growing number of educators and economists see it, the traditional classroom, with its strong central authority and its emphasis on training students to take orders and perform narrow tasks, may have prepared children adequately for work in 20th-century factories. But it can't impart the skills they need in the workplace of the 21st century, where there's a premium on workers who are flexible, creative, self-directed and able to solve problems collaboratively.

Besides, analysts argue, knowledge is changing so rapidly that teaching an established body of facts is of little value. It's more important now, educators say, to give students the skills to go on learning throughout their lives. "In 1850, it took about 50 years to double the world's knowledge base," notes Frank Withrow, director of learning technologies for the Council of Chief State School Officers. "Today, it takes only a little more than a year. The way we store, retrieve and use information is vastly different in the information age. . . . The American work force does not need 'knowers,' it needs 'learners.' "[5]

In the early days of computers in classrooms, critics worried that technology would undermine the role of schools in socializing children. But networking advocates say that linking computers actually increases social interaction and collaboration. "The Internet is much, much more than just a vast library of information: It is also a community . . . a gathering place . . . where you can find experts on almost any topic . . . and share your expertise with the world," says the Online Internet Institute, one of various groups that introduce teachers to computer networking. "This is a place where collaboration and synergy occurs, where the results and benefits you experience far exceed the sum of their individual parts." [6] (*See story, p. 932.*)

Further, advocates argue that computer networking, by conveying the printed word electronically, combines the speed and immediacy of the oral

tradition with the opportunity for more considered communication associated with the printed word. And they contend that computer-based communication allows just enough distance that artificial social barriers — including the segregation of children from the rest of society (and even each other) in age-graded classrooms — lose their relevance.

"Kids need lots of interaction with adults," says Mary Ellen Verona, a computer sciences teacher at Blair High School and principal investigator for the Maryland Virtual High School Project, which seeks to link schools for collaborative learning projects. With networking, she argues, "school becomes part of the real world. It's no longer an age ghetto."

Instant communications have become so much a part of American life, she adds, that it is becoming increasingly difficult for schools to operate without them: "You can't expect to keep kids interested with five- or 10-year-old textbooks when they're exposed to instant information on CNN and computers at home."

One thing is clear: Computer networking has unleashed tremendous enthusiasm in schools that have it. "My curriculum has never been so up-to-date, so exciting for me," says Patricia Weeg, who teaches at Delmar (Md.) Elementary School. Using KIDLINK, a grassroots project that has drawn 37,000 students together, Weeg's students have established computer "keypals" in Finland, Russia, Tasmania, Japan, Brazil and elsewhere. They have talked about the pyramids with an Egyptian schoolgirl named Mariam, learned from kids in Alaska about life in a remote village and taken a "virtual tour" of the Thames River with a British teacher.

"Are we linked to a larger teaching and learning community?" asks Weeg. "You bet we are! . . . In the global classroom, the curriculum is a 'living' curriculum with real people — not textbooks — feeding our desire to learn and explore."

For many teachers, originating communications is at least as important as receiving them. Mary O'Haver, a teacher at Fairland Elementary School, near Montgomery Blair, has turned her fifth-grade social studies class into a veritable publishing empire. Her students have used desktop publishing skills to prepare handsome autobiographical newspapers. On their web page, they have presented commemorative stamps on the Bill of Rights and important figures in American history. Several, like Christine Brewer, who prepared a report on Pocahontas, have received e-mail from far-flung readers.

Joyce Brunsvold, a Fairland reading teacher, says children are more motivated when they know they're actually communicating with people beyond school. "Kids know that parents and teachers are going to say 'Good job,' " she notes. "But when a total stranger sends e-mail commenting on something you wrote, it means a lot more." In addition, Brunsvold says, children find it easier to write and edit on the computer — and hence, do more of both.

Being connected has a pronounced impact on teachers, too. O'Haver spends relatively little time lecturing or policing behavior. And she has exchanged ideas about teaching and even conducted some joint classes with teachers in Tasmania and British Columbia. She also plugs in to MDK-12, an on-line network for teachers hosted by the University of Maryland. In short, networking has banished the classroom teacher's traditional isolation. "Who would have thought this electronic device could bring me so many friends?" asks O'Haver.

For O'Haver, part of the process of lesson planning is searching the Internet for new connections for her students. One day she stumbled upon Monarch Watch, a research project launched by University of Kansas entomologists. Using the Internet, they have enlisted an estimated 20,000 students nationwide to help track the annual migration of monarch butterflies. Students catch monarchs, tag them and report on any tagged butterflies they find.

The idea of grade schoolers participating in real research and learning from actual scientists is almost as captivating as monarch butterflies themselves. But as yet there is no agreement that it's worth the investment that would be required to achieve it.

"Schools are faced with an enormous price tag, but they're looking at shrinking state budgets and an attack on federal investment in education," notes Michelle Richards, federal networks advocate for the National School Boards Association. "The only recourse they have, other than cutting existing programs, is to raise local taxes — and most communities aren't willing to do that."

Whether advocates of networking can build the sustained public support needed to connect schools depends, in large part, on the answers to three basic questions:

Does computer networking really enhance learning?

There is no simple answer. Hundreds of studies suggest that computers can be effective teaching tools, though not dramatically better than other technologies or traditional instructional methods. But most of this research has focused on earlier, self-contained uses of computers, and therefore may be of limited value to the current debate over networking. (*See "At Issue," p. 937.*)

Moreover, many of the analyses suffer serious methodological flaws. In a 1985 review, Richard Clark, an education professor at the University of Southern California-Los Angeles, found that researchers frequently failed to distinguish the effect of computers in the classroom from that of the teachers delivering the instruction.

How an Imaginative California School District . . .

Forget "back to the basics." In northern California, some students are using computers to communicate with scientists about the future of aviation. Others are tapping into the Canadian Meteorological Center to study weather patterns. Still others are offering advice to governments — actual state governments and foreign countries — on how future population trends may affect demand for various services.

That's not all that's happening in the cyberspace of the rural Mendocino Unified School District. Teenage girls communicate with professional women about careers, and deaf students learn how to use the Internet, a powerful communications medium where being unable to hear is no disadvantage.

Deep in cyberspace in Mendocino, Calif.

All these activities, and more, are described in detail on the school district's own Internet web page.[1] Together, they demonstrate many of the pedagogical ideas that increasingly have come to be associated with computer networking — including an emphasis on interdisciplinary study, collaborative projects, active learning and use of the Internet both to gather information on topical issues and to communicate with people far beyond school walls.

They're a far cry from the "three R's" that today's grandparents were taught, or even the "new math" and other innovations introduced during the school days of today's parents. Consider, for instance, "Flight: the Confluence of Technology and Dreams," a 12-week course at Mendocino Grammar School.

Students begin by studying ancient myths — Icarus, Pegasus and others — that gave voice to man's desire to fly. Then they read about the actual historical figures — from Leonardo da Vinci to the Wright brothers to today's aerospace manufacturers — who made human flight a reality. Next, they study the physical science of flight, using computer-simulated glider designs as well as low-tech tools like paper airplanes.

At that point, the students go where few textbooks can go first to a vast store of information available over the Internet about current flying machines such as the Harrier jet, and then directly to on-line aviation-discussion groups, where they make contact with aeronautical engineers who share their own dreams about the aircraft of the future.

In the final stage of the project, students organize into teams to create their own ideal airplanes of the future and discuss the technical, economic and other barriers that would have to be overcome to make the dreams a reality.

"The underlying idea for this unit is to connect the human dreams of flight with the technological changes which . . . make those dreams come true," write teachers Deena Zarlin and Claire Skilton, who designed the course.

The Mendocino curriculum was launched three years ago. School officials wanted to establish an Internet connection, but the rural community had no local access to the vast computer network. Enter the National Aeronautics and Space Administration (NASA), which provided equipment, technical advice and access to the Internet via its Ames Research Center in Sunnyvale, Calif. "In return, we developed a curriculum for NASA," notes school Superintendent Kenneth Matheson.

NASA, whose 1958 charter requires it to disseminate its findings, is probably more involved in education than any federal agency other than the Department of Education itself. Several Mendocino courses, including the one on flight, make use of NASA's abundant on-line resources. In another class, fifth- and sixth-graders plumb such NASA data sources as SPACELINK, which provides technical information about the space program, to study the solar system.[2] The students then construct a slide show using ClarisWorks, a software package, describing a voyage to a chosen celestial body.

Not all the projects take students so far from home. A course on earthquakes is of definite local interest in Mendocino, which sits just one mile from the infamous San Andreas fault. In the class, sixth-, seventh- and eighth-grade students use the Internet to collect updated reports on seismic activity from the U.S. Geological Survey, plotting

Much of the supposed beneficial impact of computers disappeared, he said, when the teacher or instructional method were held constant.

Clark also reported that computers generally were credited with having the biggest effect in short-term studies. This suggested that much of the gain associated with computers may have resulted from the novelty of the new technology, rather than some underlying advantage.

"The best current evidence is that media are mere vehicles that deliver instruction, but do not influence stu-

. . . Takes Students Where Textbooks Can't Go

the results on a map.

As with most of the other Mendocino courses, there's an active-learning component. Students analyze their own school to determine its state of readiness for earthquakes and prepare a video for the school board showing how it would fare in an actual emergency. And there's a strong communications element, too: Again using the Internet, students compare notes with kids in other areas prone to major natural disasters.

While it's commonly assumed that computer networking is useful primarily in studying math and science, the Mendocino curriculum involves all disciplines. In a creative-writing course, students exchange observations about themselves and their communities with students around the world. Computer matches are made by the Arlington, Texas-based World Classroom, one of several organizations that link students in various parts of the country and world.[3]

The project isn't unusual. Some of the earliest uses of computer networking involved writing, rather than scientific, projects. FrEdMail, a school networking project that sprang up in San Diego in 1985, grew out of the "process writing" movement, a teaching theory that suggested students would write more — and better — if they "have an interested, sympathetic audience and they have something to say," notes Al Rogers, the founder.

Networking proponents say that "having something to say" happens when students can write about issues of immediate importance to their lives. Bronwyn Rhoades, a teacher at Mendocino High School, uses the Internet in his expository-writing course to ensure such immediacy in student projects. "Through the use of telecommunications, students can search and analyze information, rather than 're'search and report," he says.

Rhoades assigns students to write "cause and effect" essays on how recent discoveries — a newly discovered gene, a new treatment for AIDS, a vaccine for Lyme disease — might affect their lives.

The new emphasis on higher-order skills, teamwork, active learning and engagement in real world exercises has even permeated one of the most traditional subjects — mathematics. In Joan Carlson's math class at Mendocino Middle School, students use calculators and other "older" technologies to learn about linear and exponential patterns of growth. But then they have to apply what they've learned to a thorny, real-world issue: population growth.

Using the Internet, students download several simulation programs designed by the geography and computer sciences departments at Virginia Polytechnic Institute and State University in Blacksburg, Va. The "GeoSim" simulation programs include HumPop, a multimedia tutorial program that explains population concepts and issues; IntlPop, a simulation program that enables students to manipulate variables such as birth rate and life expectancy to see how they affect changes in overall population; and MigModel, which enables students to explore what factors affected migration to the United States at various times.[4]

Carlson next takes her students from simulation to real life. As a final project, students are required to project the future size of the population for a particular state or country. Then, they must analyze how population growth will affect a particular service, such as schools or public transportation. And when the analysis is finished, they must prepare a report to be sent to the appropriate government agency of the country they have analyzed.

Carlson says the goal is to stimulate students' thinking and imagination and make math interesting. "The addition of a telecommunications component . . . will only increase students' interest in these projects, as well as help them get ready for the use of this powerful tool in the real world," she adds.

While exciting, such projects aren't cheap. Like a lot of schools that have pioneered school networking, Mendocino benefited from some generous benefactors — including a number of private companies in addition to NASA. Realizing that the largess couldn't continue forever, the school district formed a nonprofit business to serve as the Internet connection for the entire community.

Numerous businesses in the area use the school's Internet service to advertise, putting whole catalogues on line. Realtors advertise. The neighboring community of Fort Bragg, now suffering from declines in the timber and fishing industries, plans to use the service to promote tourism.

Superintendent Matheson says the business expects to build its client base from 400 last spring to 1,000 by year end, producing enough revenue to pay for the school's entire telecommunications budget. But the benefits are more than financial, he says: "This has been a boon to the whole economy, and for the schools, their relationship to the community at large is very healthy."

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[1] The district's Internet address is: http://ww.mcn.org.

[2] The SPACELINK address is: http://www.spacelink.msfc.nasa.gov.

[3] World Classroom's Internet address is: telnet:global1.glc.dallas.tx.us.

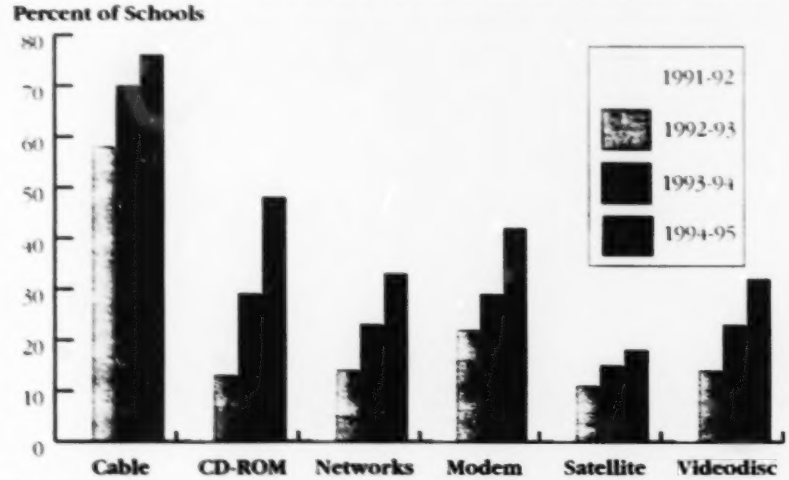
[4] The Internet address for the GeoSim program is: http://geosim.cs.vt.edu.

dent achievement any more than the truck that delivers our groceries causes changes in nutrition," Clark concluded. "Only the content of the vehicle can influence achievement."[5]

In recent years, most educators have come to agree that technology cannot be considered separately from the whole context in which it is used — including, especially, the philosophy and style of individual teachers and schools. "We know that technology may have important contributory effects to learning, but that they are crucially mediated by social practices in

Technology in Schools

Public schools are increasing their use of new technologies. During the 1994-95 school year, more than three-fourths used cable TV for student instruction, nearly half used CD-ROMS and more than a third used local area computer networks.



Note: Figures for cable TV were not available for the 1991-92 school year.
Source: Quality Education Data Inc.

the classroom by teachers and students," says Roy D. Pea, an educational researcher at Northwestern University.

Still, technology advocates and education reformers worry that traditional methods for assessing student learning fail to gauge the skills most closely associated with computer networking. While standardized tests and other common assessment tools measure student mastery of discrete skills and factual knowledge, these analysts argue, they don't adequately determine whether students are acquiring such "higher-order" skills as the ability to solve problems, think analytically, synthesize information from diverse sources and communicate effectively.

Perhaps because of the lack of adequate research findings, the impact of computers and computer networking on higher-order skills is intensely debated. Critics contend that networking can militate against these skills by undermining the relationship between teachers and students. As they see it, many teachers who use the Internet in the classroom confuse access to information with real knowledge, and mistakenly put the capacity to compile data ahead of the ability to analyze and understand it.

"Isolated facts don't make an education," writes Stoll. "Meaning doesn't come from data alone. Creative problem solving depends on context, interrelationships and experience. . . . And only human beings can teach the connections between things." [9]

Some research, however, does support the claim that networking, if properly used, helps students develop higher-order skills. In one study, Margaret Riel, a professor at the University of California at San Diego, found that fourth-graders in California, Hawaii, Mexico and Alaska who participated in an on-line news service called "Computer Chronicles" showed marked improvement in reading and writing skills compared with other students. Riel concluded that editing other kids' writing is more effective than looking for one's own mistakes, and that students felt more comfortable editing the work of distant peers than that of their own classmates. [10]

Another study by Riel suggested that students perform better when they're given authentic tasks rather than make-work assignments. In the study, judges were given two sets of papers written by Israeli students — some written for a student network and others for teachers. Without knowing for whom the papers were written, the judges found the writing done for peers was more substantive, supported more effectively by details, used less slang, had more complex constructions and contained fewer errors. [11]

The Software Publishers Association reported similar positive evaluations of the National Geographic Society's Kids Network, in which fourth- and fifth-graders collected data on acid rain and shared their data on-line with remote classes. The students showed substantial gains in the ability to organize, represent and interpret data, plus increased understanding of geography and environmental issues. [12]

While considerable work is being done to develop newer methods for assessing student performance, it may not be easy to sell the public on them. The new measures rely more than standardized tests on subjective evaluations of performance. And like the more complex phenomena they are designed to gauge, newer assessment tools are harder to reduce to simple, quantifiable scores; how, for instance, do you reduce to a single, SAT-type score a student's ability to engage in sustained intellectual inquiry or participate effectively on a team of researchers?

The Belridge School in McKittrick, Calif., learned first-hand about the pressures parents and school administrators can apply for quick, quantifiable results. A few years ago, it invested heavily in computers and software, laser disc players and television-production equipment in an attempt to revamp its curriculum. After acquiring the technology, the school

assigned students such challenging and authentic projects as producing their own television news shows and running a computer-based presidential election. But when standardized test scores two years later didn't show any improvement, parents picketed the school and elected a new school board to find a "back-to-the-basics" principal. Computers were removed from students' desks. [14]

Are teachers adequately prepared to take advantage of computer networking?

Even if all the obstacles are overcome and the nation's classrooms do become linked to computer networks, there is no guarantee that teachers will be able to make effective use of the new technology. Inadequate teacher training is limiting the potential for computer-driven school reform.

"What's going on at the high-end schools is very exciting. But at the vast majority of schools, teachers don't have any way to figure out what this is all about, and they're certainly not equipped to incorporate it into the curriculum," says Martha Matzke, director of special projects for the American Federation of Teachers.

Not only must teachers master computer technology itself, they also must learn entirely new ways of running their classrooms. "Teachers are nearly unanimous in concluding that in the early stages of technology implementation, at least, their job becomes harder," conclude the authors of a 1993 study conducted for the Department of Education. [15]

As students assume a bigger role in setting their own educational agendas, rather than simply absorbing a uniform body of knowledge, teachers must know their subjects better than ever. Otherwise, they may have trouble responding to student questions, or, worse, may feel too insecure to allow students freedom to explore independently.

Moreover, as course work evolves from a prescribed curriculum to more open-ended inquiry, teachers must learn techniques for guiding student research. For many teachers, who themselves learned in teacher-centered classrooms, this isn't easy. The inability of some teachers to help students design valid research projects has been the source of frequent criticism of how computer networking is practiced in classrooms. Stoll, for instance, writes about students who used the Internet to collect information on pizza prices around the country but never came up with meaningful explanations for the variations they discovered.

"They were learning the wrongmost thing about geography — that data collection is an end in itself," he writes. "It's usually the easy part of research, and the part requiring the least thought." [16]

In the reformed classroom, where students are encouraged to work collaboratively, teachers also need to develop skills both to evaluate group performance and to pinpoint problems individual students are having. And, perhaps most important, as students become more independent and self-directed, teachers must learn to relate to them as "guides on the side" rather than "sages on the stage."

"A teacher has to be able to say, 'I don't know everything about a subject, and it's OK if a student knows more than I do,' " said Susan Ragan, a computer sciences teacher at Montgomery Blair.

Despite the obvious need for more training, school districts in many cases find it easier to acquire computers than to help teachers learn to use them effectively. On average, schools devote less than 15 percent of their technology budgets to training, according to a 1995 report by the Office of Technology Assessment (OTA). It said the figure should at least be doubled.

The now-defunct OTA also found that most teacher-training programs at colleges made little use of technology. And it said the typical approach to teacher in-service training — short courses on specific computer applications or other single topics — may be particularly ineffective in preparing teachers to use computer networking in their classrooms. As most computer-users can testify, learning a new software program requires hands-on practice. Continuing support of a good mentor also is important, yet only 6 percent of elementary schools and 3 percent of secondary schools employed full-time computer coordinators in 1992, according to the OTA. [16]

Even when teachers get training in the fundamentals of using computers, they often don't get assistance in figuring out how to integrate the new technology into the curriculum. Jamieson McKenzie, director of technology, media and libraries for the public schools in Bellingham, Wash., recalls visiting one high school in the Northwest that had separate computer labs for the sciences, social studies and English — and teachers who were better trained than faculty at most schools. "I talked to the business education teachers, and they all knew how to do spread sheets," he says. "But when I asked them how they could use spread sheets in class, no one had any idea."

Beyond the need for training, one of the biggest problems teachers face may simply be a lack of time — time to explore the Internet themselves, develop appropriate lesson plans, assess student performance, maintain contact with parents and keep pace with advances in teaching and their own academic subjects.

"Teachers are given very little compensated staff development time, and there are multiple competing demands for this time," the OTA said. "Unless there are significant changes to the rhythm of the school day or changed incentives for giving teachers more time to learn and experiment with new technologies, this barrier to technology use will remain immense." [17]

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Field Trips of the Future

The old-fashioned field trip — an afternoon at the zoo, perhaps — seems pretty tame compared with the virtual voyages some kids are taking these days by way of technology.

The Jason Foundation for Education, for instance, uses live video broadcasts and computer connections to "take" a half-million or more students to such exotic places as a Hawaiian volcano, the Mayan ruins of Belize and hydrothermal vents in the Sea of Cortez. A similar project, Passports to Knowledge, has conducted a video trip to Antarctica and plans subsequent ones aboard a NASA aircraft that observes the stratosphere at 45,000 feet and into the heavens via the Hubble Space Telescope.[1]

Middle-school students in Rhode Island watch the live broadcast of a Jason Foundation expedition off the coast of Mexico.

Advocates believe that video field trips can lend excitement and immediacy to the learning experience. But groups like the Jason Foundation are committed to delivering more than just interesting television programming. The Jason project, for instance, offers teachers an interdisciplinary curriculum guide of several hundred pages. Each expedition offers students opportunities to engage in hands-on learning and collaborative research projects. While the centerpiece of the project is some 60 hours of video (including about six hours transmitted live from the expedition site), students and teachers also receive news and updates by computer, and they are encouraged to participate in on-line discussion groups.

The Jason expeditions were launched by Robert Ballard, the famed explorer who found the *Titanic* in its ocean grave. Last year, his expedition took participants to Kilauea volcano in Hawaii. The project included five curriculum units. The first — "Where are We Going and Why?" — drew an analogy between the Hawaiian Islands and "Island Earth," focusing both on island ecology and our place in the solar system. The second dealt with technology and featured planetary probes, robots and space vehicles, as well as data-gathering, remote sensing and computer communication equipment. The third delved into the nature and origins of volcanoes and seismic activity. The fourth looked at living organisms and their environment. And the final unit examined the history, culture and people of Hawaii both before and after Europeans arrived.

Along the way, students also received information from Rosemary Gillespie, a professor of zoology at the University of Hawaii, about spider populations on the island state. Students didn't just watch the show, though. Gillespie had them identify and report on spiders near their homes. About 125,000 spiders ultimately were counted, and the results were posted, along with the scientists' comments about them, on the project's Internet web site.

Modern telecommunications technology also is making more traditional field trips — like a visit to the museum — more available than ever before. For instance, students, teachers and others now can visit the Smithsonian Institution's Ocean Planet exhibition via computer, without ever leaving home.[2] The online version essentially recreates the exhibition in Washington, but it actually offers cyber visitors more information than the real exhibition.

Taking an electronic stroll through the exhibition, the visitor follows a floor plan that mirrors the real one in Washington. After clicking on the ocean science "room," for instance, the visitor is offered 21 topics to choose from. One, "How Deep Can They Go?" leads to an artist's rendering of the undersea world, showing the depth at which various creatures and objects have been observed.

By clicking on the picture of the shipwreck (which turns out to be *HMS Titanic's* final resting place 12,500 feet below the surface), the cyber traveler is linked to a wealth of on-line resources far beyond the walls of the museum. Among other things, he can search a folk-music database for songs that contain the word "Titanic" and view an on-line exhibit highlighting the *Titanic* in a study of how newspapers aid historical research.

To adults unaccustomed to cyber travel, the many temptations to stray can be a bit frustrating. But Gene Feldman, the NASA scientist who built the exhibition's on-line version, says that quality appeals to children.

"You've got to grab kids when they're interested," he says. If a child happens upon the *Titanic* while visiting the Ocean Planet exhibition and is interested, he argues, that's the time to tell them more. By the time you can get to a library — or even back home to check your encyclopedia — the child's interest probably has been deflected elsewhere, Feldman says.

So fasten your mental seat belts. An on-line trip to the museum may take you any number of places you never imagined you'd go. Back at the Ocean Planet exhibition, for instance, one more click of the mouse on the drawing of the *Titanic* transports a visitor to . . . the Jason Foundation.

[1] The Jason Foundation is at: http://seawifs.gsfc.nasa.gov/JASON.html. Passports to Knowledge is at: http://quest.arc.nasa.gov/livefrom/passport.html.

[2] Ocean Planet is at: http://seawifs.gsfc.nasa.gov/ocean—planet.html.

Will computer networking promote equality or widen the gap between poor and affluent Americans?

Proponents of computer networking often tout it as a great equalizer. In the on-line world, they note, differences based on age, ethnicity, race, gender and disability disappear. "It's the only real place we have where all prejudices go away," says Shelley Moses-Reed, former chairwoman of the Telecommunications Policy Advisory Committee for Colorado Springs, Colo.

But in practice, the introduction of networking into schools hasn't erased all social divisions. And there is a very real chance that the current uneven spread of computer-based communications actually could perpetuate, or even exacerbate inequality; that's because — so far, at least — children with affluent or well-educated parents have had far more opportunities than other students to use computers in developing higher-order skills.

The main source of the problem isn't uneven deployment of computer hardware, although that is a concern. Data compiled by Quality Education Data Inc. show that the average black student attends a school with just 4 percent fewer computers per student than the average white student. And Chapter 1, the federal program that distributes more than $8 billion annually to schools with disadvantaged students, has helped narrow computer differences between rich and poor schools; elementary schools where more than 25 percent of the students are eligible for Chapter 1 actually have 16 percent more computers per student than average. [18]

Hispanic students generally have less access to computers, however. And secondary schools with numerous Chapter 1 students tend to lag behind more affluent schools. Moreover, schools in central cities and those with large populations of minority and low-income students usually aren't as well-equipped as other schools to handle computer networks. A 1995 report by the General Accounting Office (GAO), for instance, showed that 60 percent of schools in central cities say their facilities have insufficient phone lines, electrical wiring or electrical power to support communications technologies. That compares with 46.5 percent of schools in rural areas and small towns. [19]

"The [infrastructure] problem is pervasive, but it's worse for schools in cities and those with large numbers of minority students," says Linda Morra, the GAO's director for education and employment issues.

But the biggest concern may be the general social environment in which students live and go to school. Children whose parents are affluent or well-educated are far more likely to have computers at home than other students; some 82 percent of students from the most affluent one-quarter of families have access to computers at home, compared with just 14 percent of those in the poorest one-fourth of families, according to a 1992 survey by the International Association for the Evaluation of Educational Attainment.

Students who are better off apparently carry this advantage to school, where they use computers as much as 20 percent more than the average student, according to the survey. And the addition of networking to school computer arsenals so far has generally widened the gap. Network use in 1992 was 70 percent higher in suburban secondary schools than for secondary schools as a whole, while black elementary school kids used networks 66 percent less than the average, according to University of California Professor Henry J. Becker. Overall, he says, computer networking is found primarily in the northeastern U.S., in suburban secondary schools, rural elementary schools and schools in higher socioeconomic communities. [20]

Within schools, advanced students usually fare better than others in the competition for computer time. At Montgomery Blair, the one computer lab with Internet connections — its 60 computers serve the school's 2,250 students — tends to be dominated by the sophisticated students in the school's highly touted math and science magnet program. Many other students stay away. "It's like starting a new job," says magnet student Patrick Toole. "They don't know where the boundaries are, so they don't take a chance of overstepping them."

"Until the funding comes for a computer in every classroom, there will still be access problems," adds Danny Mason, another Blair student. "It will probably be years before this problem is really ever solved, so I'm past hoping right now."

Finally, there are sharp variations in the ways different students use computers. While a few students learn to use computers for higher-order activities, many others use them only for rote learning through repetitious drill-and-practice routines. "Economically disadvantaged students, who often use the computer for remediation and basic skills, learn to do what the computer tells them, while more affluent students, who use it to learn programming and tool applications, learn to tell the computer what to do," writes Delia Neuman, a professor at the University of Maryland College of Library and Information Services. [21]

Unless disadvantaged students are introduced to the more exciting uses of computers, some analysts warn, they may be consigned to a new technological underclass.

"Many students become familiar with information technologies in a general sense. But those who cannot claim computers as their own tool for exploring the world never grasp the power of technology," writes Charles Piller, who reported finding sharp differences in 1992 between how affluent and disadvantaged kids are taught to use computers. "Such students become passive consumers of electronic information. . . . Once out of

school, they are relegated to low-wage jobs where they may operate electronic cash registers or bar-code readers. They may catch on as data-entry clerks, typing page after page in deadly monotony. They are controlled by technology as adults — just as drill-and-practice routines controlled them as students." [22] ■

BACKGROUND

Barriers to Use

The computer isn't the first new technology to excite the imagination of educational reformers. Motion pictures, radio, television and even the airplane also were seen initially as tools that would open the classroom to the outside world and greatly increase what students learn and how fast they learn it.

In 1922, for instance, inventor Thomas Edison optimistically predicted that the motion picture "is destined to revolutionize our educational system, and . . . in a few years it will supplant largely, if not entirely, the use of textbooks." [23]

But hopes such as Edison's have been repeatedly dashed. Invariably, after the first gush of enthusiasm, new technologies have been used far less than proponents envisioned, and the traditional structure of schools has remained largely unchanged. Students are generally segregated by age in classrooms dominated by teachers; the curriculum is divided into discrete units of knowledge and skills; and standardized tests periodically gauge students' achievement.

The tradition of teacher-centered classrooms has proven particularly impervious to change. According to Stanford University historian Larry Cuban, the tradition is rooted partly in cultural beliefs that "teaching is telling, learning is listening [and] knowledge is subject matter taught by teachers and books." It also has been shaped by practical considerations — namely, that schools must educate millions of students from diverse backgrounds, and that teachers have to maintain control of classrooms and keep students focused. [24]

In many respects, computers have had no greater impact on classrooms than earlier technologies. In its 1992 survey, the International Association for the Evaluation of Educational Attainment (IEA) found that students spend, on average, just two hours per week actually using computers in school. And most of their exposure comes in courses about computers rather than in academic subjects. Fewer than 3 percent of students used computers in science, social studies, foreign language or industrial arts courses even 10 times during a school year. [25]

Moreover, when computers were first introduced into schools, teachers used them primarily to supplement traditional teaching methods, rather than to revise fundamentally the way classrooms operate. In a 1983 survey, the University of California's Becker found that computers were used primarily to teach computer literacy and for drill-and-practice programs. [26] More recently, schools have sought to use them more to develop higher-order skills such as writing, analysis and synthesis. Becker concluded from the 1992 IEA data that about one-fourth of the time fifth-grade students spent at computers is devoted to these higher-order activities. He said the proportion rises to 44 percent for eighth-graders and to 50 percent for students in the 11th grade. Becker said the results "are not as disappointing as might be expected, but they certainly leave much room for improvement." [27]

During a recent visit to one elementary school in the Northeast, McKenzie, the school technology director, found that the familiar patterns of use still hold today. "They had one computer per classroom," he says. "None of the computers were networked. In eight or nine out of 10 classrooms I visited, the computers weren't even being used."

When the children did get to use the computers, the activities were less than inspiring. "They most often were used to reward the kids who were the best students and had finished their seat work," McKenzie notes. And even then, the computers were loaded with drill-and-practice software, augmenting the regular curriculum rather than changing it.

Reform advocates also complain that the common practice of concentrating computers in separate computer labs, rather than spreading them throughout classrooms, limits their educational value. Half of all school computers are installed in computer labs. With another 15 percent scattered between libraries, offices and other special instructional rooms, there are so few in regular classrooms that it's almost impossible for most teachers to make them a focal point for student learning.

Early Role Limited

The pedagogical theories that prevailed in the years when computers were first being introduced in schools tended to bolster the notion that technology should be used to reinforce traditional teaching styles. In particular, behaviorism, which strongly influenced educational practices in the 1950s and '60s, held that teachers should seek to produce observable and quantifiable results. The main technique to achieve this was "operant conditioning" — that is, reinforcement for desired behaviors.

Translated to the educational arena, behaviorism helped foster a school of educational practice known as programmed instruction. It was characterized by "clearly stated behavioral objectives, small frames of instruction,

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Chronology

1960s *Early efforts to use computers in education focus largely on individualized drills and skill-building, rather than communication and collaboration.*

1962
Control Data Co. links classroom-based terminals to a central, mainframe computer. The system is cumbersome and expensive, and a hoped-for revolution in learning fails to materialize.

1967
LOGO, a programming language designed to teach thinking skills, is used to teach math to fifth- and sixth-graders in Lincoln, Mass.

1968
President Lyndon B. Johnson orders the National Science Foundation to take the lead in supporting computer use in schools.

1980s-1990s

Personal computers greatly increase use of computers in schools, though drill-and-practice remains the most common application. As computer networking becomes more efficient, schools begin incorporating computer-based communications into their curricula.

1983
Warning of a "rising tide of mediocrity" in public schools, the National Commission on Excellence in Education recommends in *A Nation at Risk* that a half-year of computer sciences be included as a high school graduation requirement.

1984
Apple Computer Corp. introduces its user-friendly Macintosh personal computer, which makes the technology much more accessible to many Americans. With a grant from Apple, Margaret Riel at the University of California-San Diego launches the InterCultural Learning Network, in which students around the world produce an electronic news service called "Computer Chronicles."

1985
Six San Diego County public schools communicate with computers using an electronic bulletin board. Similar systems are established the next year in Philadelphia, Puerto Rico, New Hampshire and Illinois. Al Rogers, the founder, goes on to establish Free Education Mail, a nonprofit organization that promotes this approach to networking in schools. FrEdMail later becomes the Global SchoolNet Foundation. The Ralphe Bunche School in Harlem introduces e-mail for its students.

1987
Some 2,000 high school students around the world participate in mock negotiations on various international issues using McGraw-Hill's Information Exchange (MIX), a communications system centered in a mainframe in Minnesota. The University of Virginia creates "Teacher-Link," a computer network linking student teachers and their supervisors with faculty at the university's Curry School of Education.

1989
With a grant from the National Science Foundation and assistance from Technical Education Research Centers, the National Geographic Society starts the National Geographic Kids Network, enabling students nationwide to collect and share data on acid rain, weather, water quality, recycling, nutrition and solar energy.

1991
Virginia establishes the Public Education Network, linking all teachers in the state and giving them free access to the Internet. The idea is widely replicated.

1992
The Ralph Bunche School in Harlem introduces the first known K-12 "gopher," allowing the school to call up databases to use the Internet to publish data for a global audience, in addition to obtaining data over it. The Consortium for School Networking, a coalition designed to promote school networking, is formed.

1993
Government, business and nonprofit-sector information becomes widely available via the World Wide Web of the Internet. The Clinton administration says creation of a "seamless web of communications networks, computers, databases and consumer electronics" can help ensure that "the best schools, teachers and courses would be available to all students, without regard to geography, distance, resources or disability."

1994
President Clinton signs the Goals 2000 law establishing national objectives for K-12 education. States are required to develop school-reform plans that include "the use of technology."

1995
The Clearinghouse for Networked Information Discovery and Retrieval reports that 993 of the nation's 80,000 schools have home pages.

Education Resources Available on the Internet . . .

The best place to plug into the dialogue about school computer networking — and to see networking in practice — is on the Internet itself. There, you can find a vast array of fascinating resources for grades K-12, ranging from esoteric discussions of educational theory to "home pages" where schools and individual students display their work. Here are some examples:

Overview of K-12 Education and the Internet

EdWeb: This useful educational web site maintained by the Corporation for Public Broadcasting includes an explanation of the development of the Internet and its relationship to education reform; http://K12.cnidr.org.

National Academy of Sciences: This is a clear discussion of how networking can lead to school reform; http://nas/edu/nap/online/techgap/welcome.html.

From Now On: The Educational Technology Journal: This on-line publication from Jamieson McKenzie, a school administrator and technology expert in Bellingham, Wash., muses on the nature of Internet-based learning and offers advice to school officials on technology acquisition and use; http://www.pacificrim.net/~mckenzie.

Information Infrastructure Task Force: The Clinton administration's interagency IITF has produced a series of papers exploring various aspects of the information superhighway. One lays out arguments for how networking can change schools and includes a useful bibliography; http://iitfcat.nist.gov:94/doc/Education.html.

U.S. Department of Education Home Page: The department provides a variety of resources on education, explains national educational policy and describes the department's activities; http://www.ed.gov/index.html. The department's own technology initiatives, along with examples of how schools are using networking, can be found at http://www.ed.gov/techno.html.

The National Science Foundation Directorate for Education and Human Resources: The NSF's web site is full of information about networking demonstrations, including the Common Knowledge Project in Pittsburgh and the Learning Through Collaborative Visualization (CoVis) Project. To find descriptions of them, first click on EHR programs, then go to the Advanced Technology Program and look for funded projects. In addition, from the EHR programs page, click on Networking Infrastructure for Education for other interesting NSF-backed projects. EHR's Division of Elementary, Secondary and Informal Education describes the now completed Global Schoolhouse project and has an archive of brief news items related to the uses of technology in education; http://red.www.nsf.gov.

Office of Technology Assessment: The OTA has been a leader in promoting creative uses of technology in schools. The future of its web site (http://www.ota.gov) is uncertain, however, since Congress has eliminated the agency. The site includes the complete text of the study *Teachers & Technology: Making the Connection*.

Clearinghouse for Networked Information Discovery and Retrieval: Created by the National Science Foundation, CNIDR hosts a number of world-wide web servers for education; http://www.cnidr.org. "John and Janice's Research Page," which can be reached through Janice's K-12 Outpost, shows results of an on-going survey of schools with Internet connections.

The Educational Resources Information Center: ERIC, a national information system supported by the Department of Education, contains over 850,000 abstracts of documents and journal articles on education research and practice for serious researchers; http://www.cua.edu/www/eric_ae/home.html.

Educational Theory and Networking

ILTWeb: The Institute of Learning Technologies, part of Columbia University, maintains this site full of fascinating electronic texts, journals and hypertext documents on the educational role of networked digital communication and multimedia; http://www.ilt.columbia.edu.

Institute for Learning Sciences: Northwestern University's ILS is dedicated to transferring innovative educational technology from the laboratory to practical applications in businesses, schools and the community. It develops educational

self-pacing, active-learning responses to inserted questions and immediate feedback regarding the correctness of the response," notes Sharon A. Shrock, an expert in curriculum and instruction at Southern Illinois University.[29] "Math Blaster," a popular software program, illustrates the continuing influence of behaviorism on educational software. Children are presented with simple arithmetic problems on a screen that looks like a blackboard. Each time students get a certain number of correct answers, they are rewarded by seeing a rocket take-off or by getting the chance to use a "laser beam" to zap pieces of trash that float by in space. Students also can win reinforcement by printing out score sheets and certificates showing how many correct answers they have gotten.

Programmed instruction via computer, or computer-assisted instruction (CAI), preserves the "transmission" model of education — that is, it perpetuates the view that knowledge is transmitted from the teacher (or the computer) to the student. "Typical CAI software provides text and multiple-choice questions or problems to students, offers immediate feedback, notes incorrect responses, summarizes students' performance and generates exercises for worksheets and tests," note Barbara Means and her colleagues in their 1993 study for the Department of Education. "CAI typically presents tasks for which there is one (and only one) correct answer; it can evaluate simple numeric or very simple alpha-

. . . Range From the Esoteric to the Practical

software for use in multimedia computers. The site includes "Engines," a "hyper-book" on how to reform the education system, especially through the use of technology; http://www.ils.nwu.edu.

Center for Research on Evaluation, Standards and Student Testing: Based at the University of California at Los Angeles, CRESST offers an array of reports on research into alternative approaches to evaluating student learning; http://www.cse.ucla.edu/.

Resources for Teachers

The Internet carries scores of sites for teachers, including discussion forums, lesson plans and projects in which kids can participate. A small sample includes the following:

KIDLINK: This grass-roots "keypal" project has drawn 37,000 kids from 71 countries into a "global dialogue"; www.kidlink.org.

Technical Educational Research Centers: TERC is a nonprofit organization that promotes innovative approaches to math, science and technology education. Its web site describes a variety of projects involving students in collaborative on-line science investigations: http://hub.terc.edu:70/hub/owner/TERC. TERC operates The Hub, an Internet publication service that disseminates reports, curricula, calendars, articles and software to educators. Hub concentrates on science and mathematics but has other educational materials as well; http://hub.terc.edu.

LabNet: This is a forum for K-12 science and math teachers to explore inquiry-oriented, project-based learning. The site offers teachers access to Presidential Awardees, Woodrow Wilson fellows and other recognized teachers, discussion groups, online collaborative projects, news and more; http://hub.terc.edu/terc/LabNet/LabNet.html.

NASA IITA K-12 Internet Initiative: The 1958 law that established NASA directed the space agency to disseminate scientific knowledge it acquires. One result, the Information Infrastructure Technology and Applications program, provides print, online and video resources to help K-12 teachers. The program's web site describes NASA's online interactive projects and grants programs and offers assistance in learning how to use the Internet in schools; http://quest.arc.nasa.gov.

The Online Internet Institute: This cooperative project brought together 400 teachers and an impressive array of mentors this summer to conduct workshops exploring ways to use the Internet. New "sessions" will be conducted throughout the coming school year. http://prism.prs.K12.NJ.US:70/0/~WWW/OII/OIIhome.html. One of the institute's guiding lights is Ferdi Serim, a Princeton, N.J., teacher and former drummer for Dizzy Gillespie. Serim reports on the institute's activities in Houghton Mifflin's GNN Education Center, which offers teachers a variety of curriculum ideas, as well as connections to education experts and other teachers; http://www.gnn.com/gnn/meta/edu/index.html.

The Geometry Forum: This project at Swarthmore College near Philadelphia is an electronic community dedicated to the teaching of geometry; http://forum.swarthmore.edu/.

Classroom Connect on the Net: This comprehensive web site maintained by Wentworth Worldwide Media provides lesson plans, science projects and numerous other classroom resources. Wentworth's "Webworld" section is full of links to important business sites and nonprofit organizations' web sites; http://wentworth.com/classroom/default.html.

Global SchoolNet Foundation: A nonprofit corporation launched by a group of San Diego teachers 10 years ago, GSN offers help to teachers in designing collaborative learning projects, publishes articles, disseminates model lesson plans, training materials and instructional videos; and provides newsgroups and discussion lists for classroom use; http://gsn.org/gsn/gsn.home.html.

Apple Computer Inc.: This site is full of information on Apple's extensive education program; http://www.info.apple.com/education/. Apple maintains a separate web site for its Apple Classroom of Tomorrow, which includes mini-summaries of the different reports conducted by Apple's research unit; http://www.info.apple.com/education/acot.menu.html.

betic responses, but it cannot evaluate complex student responses." [29]

Computer-assisted instruction remains probably the most common use of computers in schools today. In its fullest elaboration, schools buy packages of hardware and software. These so-called integrated learning systems teach students "isolated bits of information and discrete skills," usually in sessions lasting 45-50 minutes. The students "have little responsibility for selecting goals or deadlines, and little chance to explore issues in depth." [30]

Despite their limitations, integrated learning systems, with their promise of one-stop shopping, have obvious appeal to school administrators overwhelmed by the complexity of buying computer hardware and software. But they aren't cheap. The typical system, which includes 30 workstations, costs about $125,000. There are about 10,000 in use in U.S. schools today, most of them purchased with funds from the Chapter I program for at-risk students. [31]

More Advanced Uses

In recent years, educational theorists have turned increasingly to a more expansive view of the role of computers. Cognitive psychology, pioneered by Jerome Bruner, Jean Piaget and Seymour Papert, emphasizes the internal process by which children learn. Among its findings: Learning requires the motivation and active participation of the student; intuition, defined as the

formation of educated guesses, is an important part of learning; and children naturally progress from being able to understand concrete matters to more abstract ones.

Cognitive psychology helped spawn the concept of discovery learning, in which students are put in situations where they must learn for themselves, rather than being told the answers by their teachers. It also gave rise to constructivism, the theory that higher-order mental skills arise not from being able to absorb and repeat facts transmitted from the teacher, but rather from dealing with complex, real-world problems.

In keeping with cognitive theory, software producers have created a number of computer programs designed to simulate real-world situations and foster the development of higher-order thinking skills. One of the first was LOGO, a programming language developed by Papert at the Massachusetts Institute of Technology (MIT). Students can use LOGO, among other things, to learn the laws of physics by programming the movement of objects. In more advanced applications, they can do everything from creating their own animated stories to designing robots.

Social science simulations also are available. With the popular SimCity, for instance, students can explore how various decisions about economics, social issues and politics affect urban development. SimEarth offers the same type of simulations on a global scale.

Such tools, however, suffer serious practical limitations, according to researchers. They are difficult to produce, and hence quite expensive. The education market is so decentralized that producers find it almost impossible to establish a market base large enough to support the investment necessary to produce such sophisticated educational tools. Teachers often have trouble integrating stand-alone software into their curriculum. And even when they do, many of the programs have a short shelf life; students are ready to move on once they have gone through them and solved the problems they pose. [32]

Networking advocates say that computer-based communications overcomes the limitations inherent in free-standing uses of computers. The supply of material available over the Internet is almost limitless and ever-changing. And in theory, at least, networking, with its emphasis on collaboration and dealing with raw reality, is the logical culmination of the constructivist quest for increased authenticity in education.

Indeed, from the beginning networking advocates have been prompted largely by a desire to engage students in meaningful activities that mirror life outside of school. In the early 1980s, for instance, researchers at the University of California began linking students with "computer pals," analogous to pen pals, on the theory that students would learn to write better if they communicate with actual peers in distant places. The exercise grew into the "Computer Chronicles" newswire, in which children in diverse places actually operated a news service.

Educators who embrace networking have come a long way from the vision of the behaviorists or the stereotypical automatons that humanists decry. McKenzie, the Bellingham, Wash., school technology director, says the goal of educating kids in cyberspace is to produce the "free-range student" — "a student fed on the wild grains and fragments available in the magical world made accessible by the [Inter]Net. . . . No more second-hand knowledge. No more sage on the stage. Students will learn to make sense out of nonsense and order out of chaos. They will ask essential questions and solve complex problems. They will join electronically with brothers and sisters around the globe to cast a spotlight on earth-threatening issues which deserve attention and action." [33] ■

CURRENT SITUATION

High Cost of Networking

By some measures, U.S. schools have made substantial strides toward entering the information age. The number of computers installed in schools has climbed from 2.4 million in 1989 to an estimated 5.8 million this spring. [34] With one computer for every 10.5 students, the U.S. now leads the world in the number of computers per student.

But a closer look takes some of the shine off those figures. More than half of the computers in U.S. schools are older-generation models, primarily Apple IIs, whose 8-bit capacity gives them relatively little processing power or storage capabilities; they can't handle much of today's software and networking activities. A number of other countries, including Austria, Japan and the Netherlands, started acquiring computers later than the U.S., and consequently have a greater proportion of modern, 16-bit and 32-bit computers. [35]

Moreover, many American schools lack sufficient wiring, electrical power, cooling and physical security to accommodate up-to-date computer networking. Only one classroom in eight is wired for telephone service. In its report on school facilities, the GAO estimated that it would cost $112 billion to repair or upgrade school facilities to meet various health and safety conditions, ensure an adequate environment for learning and allow for full use of technology. [36]

Beyond that, it isn't yet clear how the substantial added cost of wiring schools for advanced telecommunications can be met. The most basic hookup —

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At Issue:

Will computer networking improve educational instruction?

CONSORTIUM FOR SCHOOL NETWORKING
FROM *BUILDING CONSENSUS, BUILDING MODELS: A NETWORKING STRATEGY FOR CHANGE*, MARCH 1994.

America's current educational system, which is largely based on an industrial factory model, needs to be revamped to meet the needs and expectations of a knowledge-based society. Today's students need to master critical information-age skills: finding, evaluating and using all kinds of rapidly changing information to solve complex problems. . . .

In the last two decades, the culture of learning has undergone significant change, and many students now have increasing opportunity to construct their own learning environments. Nonetheless, learning in many places continues to be predominately passive: Teachers use "chalk and talk" to pour "knowledge" into student's heads — particularly in urban and other public schools where the teacher is responsible for very large numbers of students, who may have different learning styles and abilities. . . .

In addition, the curriculum, or content of learning, is often rigidly defined. Textbooks may be reviewed and replaced at five-year (or longer) intervals. . . . Typically, curriculum is not multidimensional, multidisciplinary or multicultural. . . . The relationship between teacher and student also remains rigidly defined: Teachers are largely expected to give knowledge and students to receive it. Many pressures and fears work against significant changes in these traditional roles. Perhaps the most notable pressures are the already heavy demands on an educator's time in any given day or hour.

Relationships among students remain largely competitive, with opportunities for collaboration and cooperation limited and carefully regulated. Since competition is the prevailing norm in American society, it is difficult for the schools alone to promote collaboration. . . .

The communication and information resources brought to the classroom by networked computers can excite and challenge all students. The student can take on all kinds of roles: explorer, world traveler, foreign correspondent, intelligence analyst, scientist, artist, musician, published author and respected commentator. With the stroke of a child's finger, global distances are traversed effortlessly, and a world of rich information resources is at hand.

As networking students gain proficiency in collecting, organizing, analyzing, evaluating, constructing and publishing knowledge, they become active learners. They acquire skills and attitudes that they will need as information-age workers. As they learn to be adaptable, creative risk-takers, they prepare for lifelong learning.

Networked learning naturally tends towards a collaborative process even as it accommodates and reflects different, individual learning styles and orientations. Learners can be less isolated and have more frequent, regular and meaningful exchanges with others of similar needs and interests — and with the "real" world.

CLIFFORD STOLL
FROM *SILICON SNAKE OIL: SECOND THOUGHTS ON THE INFORMATION HIGHWAY*, DOUBLEDAY, 1995.

All of us want children to experience warmth, human interaction, the thrill of discovery and solid grounding in essentials: reading, getting along with others, training in civic values.

Only a teacher, live in the classroom, can bring about this inspiration. This can't happen over a speaker, a television or a computer screen. Yet everywhere, I hear parents and principals clamoring for interactive computer instruction. . . .

In the past, schools tried instructional filmstrips, movies and television; some are still in use, but think of your own experience: name three multimedia programs that actually inspired you. Now name three teachers that made a difference in your life.

I do remember that whenever I saw an educational film in high school, it meant fun for everyone. . . . Computers and the Internet do the same — they make it easy for everyone, but damn little teaching happens.

What's most important in school? Working with good teachers who can convey method as well as content. Except to the extent that students are involved with a caring teacher, schooling is limited to teaching facts and techniques. In this sense, network access is irrelevant to schooling — it can only prevent this type of interaction. . . .

I suspect that most schoolteachers know that there's little value in just getting on the Net and retrieving stuff. You might as well walk into a library and randomly pick books off the shelf. . . .

Maybe computing should be integrated with other classroom activities. Sounds tempting — combine computing with math, physics or history. In a sense, we teach students to become information hunter-gatherers. Tell them how to access online resources and make sure they're comfortable finding their way around the networks.

This assumes that most everything is available online and that networks use simple, standardized tools. It also assumes that primary source material isn't messy and that students will know how to use the data presented to them. I doubt that any of these assumptions are valid.

There's a deeper assumption: that gathering information is important. These teaching projects magnify the computing side, while making the learning experience seem trivial. . . .

The Internet can deliver all the information taught in a university, as can a good encyclopedia. So why go to college?

Because isolated facts don't make an education. Meaning come doesn't come from data alone. Creative problem solving depends on context, interrelationships and experience. The surrounding matrix may be more important than the individual lumps of information. And only human beings can teach the connection between things.

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providing every school a single connection using a modem over a standard telephone line — would cost about $80 million for installation and $560 million annually to operate, according to MIT researcher Russell Rothstein. [57]

But few teachers or students could make use of such a limited connection. A more comprehensive approach — in which computers within a school would be linked together, several students could connect with the Internet simultaneously and a higher-capacity telephone link would allow transmission of video and other advanced applications — could cost as much as $27.5 billion for installation, plus another $4.9 billion in annual operating expenses. [58]

Of course, cost estimates must be viewed cautiously because technology is changing so rapidly. But by any estimate, schools would have to increase their technology spending substantially to become connected. Elementary and secondary schools currently spend a total of $249 billion a year, according to a McKinsey analysis for the Clinton administration's National Information Infrastructure Advisory Council. Technology accounts for about 1.3 percent of that total. To provide enough advanced computers and telecommunications links for networking to play a significant role in the curriculum, McKinsey estimates, technology spending would have to rise to more than 4 percent of total school spending.

Government Initiatives

Given the cost, it's clear that schools won't be wired for computer-based communications overnight. But much is being done — at the federal, state and grass-roots levels — to make networking in schools a reality.

President Clinton has set four priorities for federal research in educational technology. As spelled out by the National Science and Technology Council's Subcommittee on Research and Development in Education and Training, the priorities include:

- Supporting demonstration projects that showcase innovative technology and networking applications. Congress cut the $27 million approved for fiscal 1995 to just $9.5 million, however, and it appears unlikely to approve anything near the $70 million the administration requested for fiscal 1996.
- Developing new models for evaluating the impact of technology and other educational tools on student learning. "It's clear we need new assessment tools," says Ram Singh, senior research associate at the Education Department's Office of Educational Research and Improvement.
- Promoting the development of new high-quality learning tools. Officials note, for instance, that some military training programs have proven highly effective, as have language-instruction methods adopted by the Central Intelligence Agency.
- Conducting basic research on learning and cognitive processes. [59]

The administration will be establishing an Interagency Learning Technology Office to coordinate the educational research activities of federal agencies. In addition, it is establishing six regional centers to give school officials information and advice about technology. Education Department officials hope the centers can help schools sift through the conflicting advice they get from technology vendors and, by aggregating demand, give educators a greater voice in shaping software and other technology development. But the centers face an uncertain future because of opposition to government spending.

President Clinton and Vice President Al Gore are expected this fall to challenge businesses to lend technical support to schools interested in using networking in classrooms. The model for the volunteer effort is the Tech Corps in Massachusetts. Set up by *Computer World* magazine President Gary Beach and the Massachusetts Software Council, the corps has organized 300 volunteers so far. Similar volunteer efforts are expected to be launched soon in at least nine other states.

State governments also are pushing networking, but they, too, face fiscal limitations. A few states — including North Carolina and Iowa — are building state fiber optic networks and offering to connect schools to them. Iowa, which decided this year to spend $18 million to begin extending the state network to schools and libraries, projects the entire undertaking will cost $96 million. And in North Carolina, schools must pay $4,000 a month to use the state network — more than many districts can afford. [60]

As a first step toward school networking, many states are pushing to get teachers connected by offering teachers low-cost or free access to the Internet. "If we can't get an Internet connection for every student, at least we can get one for every teacher," says Kathleen Fulton, who directed the OTA's study on teachers and technology. She says connecting teachers would be very "doable," and would go a long way toward breaking down the professional isolation of teachers while building a powerful constituency for expanding computer-based communications for schools.

Other Networking Efforts

Meanwhile, networking advocates increasingly are emphasizing the importance of training teachers and building support for systemic reform of education.

The Boston Computer Society, for instance, has embarked on an ambitious project to make every teacher in Massachusetts computer-literate. The volunteer group, based in Waltham, Mass., originally approached Raytheon Corp. for funds to offer computer training to a small group of "non-moti-

vated" students. But the company prodded it to think bigger. "They wanted a program where all the teachers in Massachusetts could have access to computer learning," says Marlene Archer, the society's public service coordinator.

The society plans to send volunteers into 50 schools to conduct teacher training this year. Archer says they'll reach every school in the state within three years.

There also is a growing awareness among benefactors that integrating technology into the school curriculum is as important as providing the hardware. Nora Sabelli, a senior program officer at the National Science Foundation, cites as an example Pittsburgh's "Common Knowledge" project, in which public schools are working with the University of Pittsburgh and the Pittsburgh Supercomputing Center to develop an electronic data network for schools. The project is being designed "from the bottom up, starting with teachers," rather than having school administrators impose it from on high, Sabelli says. [41]

Tax-deductible donations of used computers to schools have long been a staple of corporate charitable contributions. But a number of companies in recent years also have been encouraging schools to use computers to promote broader education reform. Last year, for instance, IBM Corp. launched a five-year grant program designed to foster systemic change in schools. Grant recipients included Charlotte, N.C., which plans to use technology as part of an effort to raise graduation standards, group students by ability rather than age, lengthen the school day and increase parent involvement.

And Apple Computer Inc. is conducting comprehensive research on computers and education through its Apple Classrooms of Tomorrow project. Now 10 years old, the project uses working classrooms to look at teacher development, the influence of computers on student learning, the relationship between technology and collaboration and other topics. "It's hard for us to talk about technology as an entity in itself," the company says. "It can't be separated from change." ■

FOR MORE INFORMATION

Consortium for School Networking, 1555 Connecticut Ave. N.W., Washington, D.C. 20036; (202) 466-6296; e-mail: membership@cosn.org. A coalition of professional groups, businesses and individuals, CoSN advocates telecommunications and education policies designed to promote school networking.

National School Boards Association, 1680 Duke St., Alexandria, Va. 22314; (703) 838-6722; e-mail: TShannon@tmn.com or CherWill@tmn.com. This federation of state school board associations operates the Institute for the Transfer of Technology to Education, which publishes materials and holds conferences relating to school networking and related topics.

U.S. Department of Education, Office of Educational Technology, 600 Independence Ave., Washington, D.C. 20202; (202) 401-1444; e-mail: linda_roberts @ed.gov. Reflecting the Clinton administration's strong commitment to school networking, the special technology office was established in 1993.

Technical Education Research Centers, 2067 Massachusetts Ave., Cambridge, Mass. 02140; (617) 547-0439; e-mail: communications@hub.terc.edu. TERC is a nonprofit organization that conducts research and develops innovative school programs in science, mathematics and technology. It provides a number of publications dealing with networking in classrooms.

OUTLOOK

Technology and Reform

Some technology enthusiasts believe that computer networking inevitably will transform the traditional, teacher-centered classroom into the student-centered one envisioned by reform advocates.

"Machines can indeed change the culture of organizations, even ones as entrenched and recalcitrant as schools," says Steven Hodas, an analyst with Sterling Software Inc. in Vienna, Va., who has helped establish a NASA program that helps K-12 schools using the Internet to develop curricula on space and aeronautics. "But they do it not, as technologists have generally imagined, by enabling schools to do the same job only better (more cheaply, more efficiently, more consistently, more equitably), but by causing them to change their conception of both what it is they do and the world in which they do it." [42]

Historians like Cuban, on the other hand, argue that networking advocates won't transform schools unless they first change the cultural beliefs and practical considerations that underlie the traditional classroom. Cuban, who has reservations about the use of computers in schools, doesn't think technology advocates have addressed these tougher issues.

"Unless existing classroom and school settings are altered substantially, much beyond the conventional will be tough to attain," he writes. "No computer advocates that I have read or heard, for example, have suggested that schools should hire more teachers and adults to reduce the teaching load, bringing it closer to the college [staffing level] than to the factory. No computer advocate urges increasing school district budgets by half to modify the existing school and classroom arrange-

ments concerning class size, governance, training and teacher collaboration. Their sole recommendation is to put money into classroom computers." [85]

A growing number of networking advocates are coming to accept Cuban's view. They agree that the success of computer networking — and even its widespread introduction — requires more than just hardware and wiring. It also depends on whether policy-makers, school officials and parents accept the underlying educational theories that support networking and whether teachers and schools get the resources and support needed to make effective use of the new technology. "Technology and reform do not necessarily go hand in hand," note Means and her colleagues. [86]

As yet, it's unclear whether Americans do accept the pedagogical theories that underlie school networking. The traditional emphasis on values education, cultural literacy and "back to the basics" seems to run in the opposite direction. So does the continuing demand for standardized testing. Cuban, for one, notes that "concentration on quantitative standards reinforced by high-stakes test results usually diminishes risk-taking in classroom and school innovations." [87]

Development of a new networking-centered curriculum, then, may require new assessment tools to measure the information age skills that reformers and technology-advocates contend are most important.

Yet one of the biggest forces promoting such a curriculum may be the students who already feel empowered by it. Back at Montgomery Blair High School, Yi-Lun Ding says, "For my kids, I think computers will be as important as notebooks in the classroom," he says. "The media center and computer labs will have many computer networks, and . . . optic fiber will probably connect networks throughout the world, allowing fast transmission of all sorts of data."

He adds, however, that "technology can only advance education up to a point, and then it's up to teachers to use the technology at their disposal to benefit the students as much as possible."

Some students aren't waiting for teachers to introduce students to networking. Students wired Blair's computer lab, and now they run it. And last spring, when the county set up a workshop on using the Internet for 120 English teachers, the instructors were a group of Blair students. ■

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Notes

[1] For background, see "Regulating the Internet," *The CQ Researcher*, June 30, 1995, pp. 561-584.

[2] Quality Education Data Inc. and Malarkey-Taylor Associates Inc., "1995 Education Technology Survey," July 1995.

[3] Russell I. Rothstein, "Connecting K-12 Schools to the National Information Infrastructure: A Preliminary Assessment of Technology Models and their Associated Costs," Aug. 4, 1994.

[4] Clifford Stoll, *Silicon Snake Oil* (1995), pp. 126-127.

[5] National Academy of Sciences, "Reinventing School: The Technology is Now," 1995. This document can be found on the Internet at the following address: http://nas/edu/nap/online/techgap/welcome.html.

[6] Quoted in Federation of American Research Networks Inc., and Consortium for School Networking, *Building Consensus/Building Models: A Networking Strategy for Change* (1994).

[7] Available from the Online Internet Institute at the following address: http://prism.prs.K12.NJ.US:70/0/WWW/OII/OIIhome.html.

[8] Richard Clark, "Reconsidering Research in Learning from Media," *Review of Educational Research*, 53(4), pp. 445-459, cited in Ann D. Thompson, Michael R. Simonson and Constance P. Hargrave, *Educational Technology: A Review of the Research* (1992), p. 1.

[9] Stoll, *op. cit.*, p. 134.

[10] Margaret Riel, *Interactive Learning Environments*, Vol. 1, 4 (1991), pp. 255-263.

[11] *Ibid.*

[12] Jay Sivin-Kachala and Ellen R. Bialo, *Report on the Effectiveness of Technology in Schools, 1990-1994* (1994), p. 13.

[13] Barbara Means et al., *Using Technology to Support Education Reform* (1993), pp. 87-88.

[14] *Ibid.*, p. 70.

[15] Stoll, *op. cit.*, p. 140.

[16] Office of Technology Assessment, *Teachers and Technology: Making the Connection* (1995).

[17] *Ibid.*, p. 25.

[18] Henry J. Becker, *Analysis and Trends of School Use of New Information Technologies* (1994), pp. 50-57.

[19] General Accounting Office, *School Facilities: America's Schools not Designed or Equipped for 21st Century* (April 1995), pp. 39-42.

[20] Becker, *op. cit.*

[21] Delia Neuman, "Technology and Equity," *Eric Digest* (1991). The Digest is a government-funded data base on educational issues; its Internet address is: http://www.cua.edu/www/eric_ae/home.html.

[22] Charles Pillar, "Separate Realities," *Macworld*, September 1992, p. 230.

[23] Quoted in Larry Cuban, *Teachers and Machines: The Classroom Use of Technology Since 1920* (1986), p. 9.

[24] Larry Cuban, "Computer Meets Classroom: Classroom Wins," *Teachers College Record*, winter 1993, pp. 185-210.

[25] Becker, *op. cit.*, pp. 33-34.

[26] Cited in Means et al., *op. cit.*, p. 58.

[27] *Ibid.*, p. 36.

[28] Sharon A. Shrock, "A Brief History of Instructional Development," in J. Anglin, (ed.), *Instructional Technology: Past, Present and Future* (1991), p. 15.

[29] Means et al., *op. cit.*, p. 13.

[30] *Ibid.*, p. 14.

[31] *Ibid.*

[32] *Ibid.*, pp. 23-24.

[33] Jamieson McKenzie, "Grazing the Net: Raising a Generation of Free Range Students — Part II," in *From Now On: The Education Technology Journal*, available on the Internet at: http://www.pacificrim.net/~mckenzie.

[34] Office of Technology Assessment, *Teachers & Technology: Making the Connection* (1995), pp. 93-94.

[35] International Association for the Evaluation of Educational Attainment, cited in *School Improvement Through Media in Education, A German-American Dialogue*, Third Conference about Media Competency as a Challenge to School and Education, Bertelsmann Foundation (1995), p. 62.

[36] General Accounting Office, *op. cit.*

[37] Rothstein, *op. cit.*, p. 10.

[38] *Ibid.*, p. 16.

[39] The National Science and Technology Council coordinates research and development activities and programs that involve more than one federal agency.

[40] Rochelle L. Stanfield, "Connected Classrooms," National Journal, July 22, 1995, p. 1888.

[41] The Common Knowledge project's home page can be found on the Internet at: http://gopher.skp.edu/home.html.

[42] Stephen Hodas, "Technology Refusal and the Organizational Culture of Schools," available on the Internet at: gopher://whitman.nsi.nasa.gov. Hodas' essay will be published in Robert Kling (ed.), *Computerization and Controversy*, forthcoming from Academic Press.

[43] Cuban, *Teachers and Machines*, *op. cit.* pp. 100-101.

[44] Means et al., *op. cit.*, p. 10.

[45] Cuban, "Computer Meets Classroom," *op. cit.*, p. 203.

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Selected Sources Used

Books

Cuban, Larry, *How Teachers Taught: Constancy and Change in American Classrooms, 1880-1990*, Teachers College Press, 1993.

A longtime educator and historian explores how the traditional "teacher-centered classroom" has endured despite various efforts to replace it with a student-centered approach.

Perelman, Lewis J., *School's Out: Hyperlearning, the New Technology, and the End of Education*, William Morrow, 1992.

A prominent polemicist of the Information Age argues that learning, once "a task of childhood in preparation for entering adult life and work," is now "literally the work of the majority of U.S. jobs and will be what virtually all adults — whether employed, unemployed or 'on welfare' — will do for a living by the early years of the 21st century."

Postman, Neil, *Technopoly: The Surrender of Culture to Technology*, Alfred A. Knopf, 1992.

Though not specifically about education, this critique of modern technological culture by a New York University communications expert faults advocates of computers in the schools for seeking to make learning "more efficient and more interesting" without addressing the fundamental question, 'What is learning for?' "

Sloan, Douglas (ed.), *The Computer in Education: A Critical Perspective*, Teachers College Press, 1984.

This collection of essays challenges the view that computers enhance education.

Stoll, Clifford, *Silicon Snake Oil: Second Thoughts on the Information Highway*, Doubleday, 1995.

These musings of a disillusioned cyber-surfer raise some interesting and important questions about whether the Internet is all it's cracked up to be — in education and in other spheres.

Articles

Cuban, Larry, "Computers Meet Classroom: Classroom Wins," *Teachers College Record*, Volume 95, No. 2 (winter 1993), pp. 184-210.

Cuban asks whether the computer will fail to transform education just as earlier technologies did. His nuanced conclusion is that while the computer has a better chance than some of its predecessors, its ultimate impact remains far from certain.

Piller, Charles, "Separate Realities: The Creation of the Technological Underclass in America's Public Schools," *Macworld*, September 1992, pp. 218-230.

Piller traveled extensively to observe how schools were using computers and came up with the chilling conclusion that "in most cases, computers simply perpetuate a two-tier system of education for rich and poor."

Stanfield, Rochelle L., "Connected Classrooms," *National Journal*, July 22, 1995, pp. 1885-1889.

Stanfield describes connecting the schools as "an exceedingly expensive proposition." She concludes that "just when it's needed most, the federal role is likely to be scaled back."

Reports and Studies

Becker, Henry Jay, *Analysis and Trends of School Use of New Information Technologies*, Office of Technology Assessment, March 1994.

A very useful analysis of recent surveys on the deployment and use of computers in K-12 education, this unpublished report may be purchased from the national Technical Information Service in Springfield, Va., (703) 487-4650, for $19.50

General Accounting Office, *School Facilities: America's Schools Not Designed or Equipped for 21st Century*, April 1995.

This report by the research arm of Congress summarizes school administrators' views of their infrastructure needs. Unfortunately, the GAO relied on subjective responses from school officials.

Means, Barbara et al, *Using Technology to Support Education Reform*, 1993.

Prepared for the Department of Education, this volume explains the pedagogical theories behind the school reform movement, describes the various uses of educational technologies, surveys research findings on the impact of technology in classrooms and discusses how reforms can fail or succeed.

Office of Technology Assessment, *Power On! New Tools for Teaching and Learning*, September 1988.

Though seven years old, this is still one of the most comprehensive discussions of the potential impact of technology in the classroom.

Office of Technology Assessment, *Teachers and Technology: Making the Connection*, April 1995.

Published shortly before Congress decided to close the OTA, this volume discusses in great detail the role of teachers in making technology work for change in schools.

Thompson, Ann D., Michael R. Simonson and Constance P. Hargrave, *Educational Technology: A Review of the Research*, Association for Educational Communications and Technology, 1992.

This is a compilation of research findings on the impact of various technologies on student learning. It puts the research in a broader context, describing how evolving theories about learning have shaped ideas about school reform and the use of technology in the classroom.

The Next Step

Additional information from UMI's Newspaper & Periodical Abstracts database

Computers in the Classroom

Hagans, Gail, "Tired of mischief, schools tackling computer etiquette," *Atlanta Journal Constitution*, Feb. 26, 1995, p. G1.

Mischief and misbehavior have taken a technological turn as schools go high-tech and more students speed along the information superhighway. As a result, metro Atlanta teachers wanting to cut time lost to computer pranks and mistakes are teaching the ethical rules of the road.

Judson, George, "Hartford schools enter new world," *The New York Times*, March 9, 1995, p. B6.

Education Alternatives Inc., the company hired in November 1994 to manage the Hartford school system, promised new classroom computers for each of the city's 32 schools installed within a year. In March 1995 Clark School is just one of two in the system with new computer labs. The challenge to the school system of making full use of the computers is discussed.

Keating, Stephen, and Mark Eddy, "Religion-in-schools stance expanded," *Denver Post*, July 14, 1995, p. B9.

The debate over religion in schools will expand to include computers in the classroom, U.S. Secretary of Education Richard Riley said on July 13, 1995, in Denver.

Lynn, Genevieve, and Anne R. Carey, "USA Snapshots: Wiring schools into info age," *USA Today*, May 17, 1995, p. A1.

According to the General Accounting Office (GAO), 86.8 percent of schools with computers lack fiber optic cables, 61.2 percent lack instructional use telephone lines, 60.6 percent lack conduit/raceways for cables, 57.5 percent lack modems and 55.5 percent lack telephone lines for modems.

Rosenberg, Ronald, "Volunteers to lend schools technological helping hand," *Boston Globe*, Jan. 28, 1995, p. 61.

Under an ambitious plan unveiled by the Massachusetts Software Council, volunteers from the business community with knowledge and experience in technology, teaching, local area networking or other technical skills will be dispatched to the state's schools to help them implement computer education.

Thurston, Belinda, "Laptops less of a luxury in schools," *USA Today*, April 3, 1995, p. D8.

Kathleen Fulton, director of the education department of the Office of Technology Assessment, a congressional agency, says the number of laptop computers in schools is small, but it's a growing trend, and policies will emerge to handle concerns such as cheating, equity and safety.

"U.S. schools found lagging in vital technologies," *The New York Times*, April 5, 1995, p. A21.

The GAO said on April 4, 1995, that a survey of 10,000 schools has found that most were not set up to make full use of computers and video. The survey found that most U.S. schools are lacking in crucial technologies, and most teachers are not properly trained to use the equipment.

West, Peter, "Technology plan for U.N.C. ed. schools approved," *Education Week*, April 5, 1995, p. 11.

The University of North Carolina system is requiring all education faculty and education majors to become proficient at using computers and software. The computer basics must be mastered by education faculty by 1996.

Woronov, Terry, "Myths about the magic of technology in the schools," *Education Digest*, December 1994, pp. 12-15.

The push to get more computers in schools is sometimes backed up by the naive assumption that the presence of computers alone will make good things happen. Myths about computers and schools are discussed.

Financing Computers

Beyers, Dan, "Montgomery schools' on-line quandry," *The Washington Post*, Feb. 13, 1995, p. A1.

Montgomery County, Md., school officials, who want to bring computers to each of the county's 179 schools, are excited about the prospect of engaging students' minds in a way that teachers' lectures never have. But the county's plunge into the technological unknown makes government leaders uneasy because the costs are so high, and the future is so uncertain.

Bils, Jeffrey, "Schools discussing ways to cooperate," *Chicago Tribune*, June 16, 1995, p. D8.

More than 50 leaders from 22 Illinois school districts met to discuss how they could save money by pooling their insurance policies, centralizing their hiring and networking their computers in Illinois' first all-purpose educational cooperative.

Hall, Charles W., "Schools chart a course into the information age," *The Washington Post*, Nov. 17, 1994, p. V1.

Arlington County, Va., school officials, saying they need to bring more students and teachers into the information age, have unveiled a four-year, $5.5 million initiative that would replace 1,400 obsolete computers and make better use of high technology in the classroom.

Heard, Jacquelyn, "Computer project OKd for 24 schools," *Chicago Tribune*, Jan. 26, 1995, p. C3.

The Chicago Board of Education overwhelmingly approved a $34 million pilot computer project that, if fully implemented, would cost the cash-strapped school district more than $600 million over five years.

Heard, Jacquelyn, "IBM gives city schools $2 million," *Chicago Tribune*, May 9, 1995, p. C2.

The cash-strapped Chicago school system received a $2 million grant to fund the design and implementation of a computer software program that will help teachers use the Internet to teach math and science. The donation from computer giant IBM will do nothing to fill the $150 million deficit that threatens to shut down the district in the fall of 1995.

Kinnaman, Daniel E., "Penn State students recycle used computers for needy schools," *Technology & Learning*, January 1995, p. 12.

SCROUNGE (Students for Computer Recycling to Offer Under-represented Groups in Education) is a volunteer student group that locates used computer systems, fixes them and donates them to schools in need of technology resources. The group was started at Pennsylvania State University.

Loar, Russ and Jeff Bean, "Funds raised for schools to buy extras may be used for basics," *Los Angeles Times*, Dec. 16, 1994, p. A27.

Thousands of dollars that PTAs and education foundations have raised for extras such as computers, music and art in Orange County, Calif.'s public schools might end up buying paper and pencils instead. The reaction of school officials to the bankruptcy crisis is discussed.

Loupe, Diane, "Lottery doles out computer cash; Schools to pick up support tab," *Atlanta Constitution*, Sept. 12, 1994, p. 1.

The Georgia Lottery pumped $2.7 million into Gwinnett County schools to purchase electronic equipment in 1993-94, but support and maintenance of the additional equipment will cost the school system local tax dollars, the school system said.

O' Harrow, Robert Jr., "Computers' second life offers schools an opportunity," *The Washington Post*, Nov. 24, 1994, p. V1.

Area businesses have donated more than 500 second-hand personal computers to Fairfax County, Va., schools in 1994 as part of a program that allows the businesses to receive tax benefits for machines they might otherwise discard.

Vanzi, Max, "Panel OKs bond issue on computers for schools," *Los Angeles Times*, July 2, 1995, p. A26.

A proposal to raise $500 million from bond sales to finance computer equipment for California schools has been approved by a legislative committee.

Teachers and Computers

Abrahms, Sally, "Introducing teachers to computers," *Boston Globe*, Oct. 2, 1994, p. C4.

Teachers in Brookline, Mass., are lining up to get online and learn about computers. As part of its five-year, $400,000-a-year technology plan, the school system has begun offering teachers free, six-week computer lessons.

Baca, Stacey, "Computers? Kids' stuff," *Denver Post*, Jan. 28, 1995, p. B2.

Students at Denver's Dupont Elementary School are teaching their parents how to use the school's MacIntosh terminals. The new after-school program has turned young students into knowledgeable teachers. It also has boosted their confidence, their ability to relate to their elders and their computer skills.

Bingham, Janet, "Computers pervasive at 10 new schools," *Denver Post*, Aug. 15, 1994, p. A8.

Ten additional and replacement schools in Jefferson County, Colo., opened the 1994 school year in August wired for modern technology with telephones for teachers and computers in every classroom. The benefits of the new computers are examined.

Bracey, Gerald, "Computers improve teaching," *Electronic Learning*, winter 1994, pp. 1-2.

The computer is a powerful tool that makes learning an active, creative process, according to an overview of educational technology research. With new computer technology, teachers are led to try out new instructional strategies.

Franklin, Marie C., "Teachers catch up on computers," *Boston Globe*, Aug. 20, 1995, p. 73.

In August 1995, computers were demystified for 35 teachers attending the first Teaching with Technology Institute at the new John Joseph Moakley Center for Technological Applications at Bridgewater State College in Massachusetts.

White, Betsy, and Reagan Walker, "Teachers not up to speed on computers," *Atlanta Journal Constitution*, March 5, 1995, p. C5.

Georgia's high-priced plunge into educational technology has touched more than a million children and provided a computer for every 10 students, but the investment is failing to deliver on its promise because most teachers lack the necessary training to use the computers and other technologies, according to a survey by the *Atlanta Journal-Constitution*. Gov. Zell Miller counsels patience and says help is on the way. Information misprovided on how educators have used computers in the classroom.

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